What is claimed is:

1. In a QAM demodulator including an adaptive equalizer, a method of carrier tracking comprising the steps of:

(A) sampling a QAM signal received from a transmission channel;

(B) recovering a symbol clock function from said sampled QAM signal;

(C) applying said sampled QAM signal to said adaptive equalizer in order to obtain a QAM equalized signal in a Blind Equalization (BE) mode;

(D) using a slicer to locate a nearest plant point for said QAM Blind equalized signal for each said recovered symbol clock;

(E) using a complex conjugate multiplier to obtain an instantaneous inphase component and an instantaneous quadrature component of a phase angle error signal by comparing an inphase component and a quadrature component of said QAM Blind equalized signal and an inphase and a quadrature component of said nearest plant point for each said symbol clock;

(F) using a phase detector to translate said inphase component and said quadrature component of said phase angle error signal into an instantaneous phase angle error for each said symbol clock;

(G) averaging said instantaneous phase angle error signal by using a carrier loop filter;

(H) using a complex multiplier to insert an inverse of said averaged phase angle error signal into said QAM Blind equalized signal to compensate for said carrier phase angle error;

and

(I) repeating said steps (D-H) to close a carrier frequency loop, wherein

said carrier frequency loop includes said complex multiplier, said slicer, said phase detector including said complex conjugate multiplier, and said carrier loop filter, and wherein said QAM input signal includes said input carrier frequency within an acquisition bandwidth of said carrier frequency loop.

2. The method of claim 1, wherein said step (B) of recovering said symbol clock function from said sampled QAM signal further includes the step of:

(B1) determining for each sample an optimum sampling point located in the center of said current sampled QAM signal.

3. The method of claim 1, wherein said step (B) of recovering said symbol clock function from said sampled QAM signal further includes the step of:

(B2) interpolating between at least two preceding sampled QAM signals.

4. The method of claim 1, wherein said step (F) of using said linear phase detector to obtain said instantaneous phase angle error for each said symbol clock further includes the step of:

obtaining said instantaneous phase angle error for each said symbol clock in a Decision Directed Equalization (DDE) mode.

5. The method of claim 1, wherein said step (F) of using said linear phase detector to obtain said instantaneous phase angle error for each said symbol clock further includes the step of:

obtaining said instantaneous phase angle error for each said symbol clock in a Blind Equalization (BE) mode.

6. The method of claim 1, wherein said carrier frequency loop further includes a 1-st order Phase (P) carrier frequency loop, and wherein said step (G) of averaging said phase angle error by using said carrier loop filter further includes the step of:

determining a set of (P)- phase coefficients for said carrier loop filter by using a state machine depending on clock counts, a measured average constellation error, and at least one error threshold.

7. The method of claim 1, wherein said carrier frequency loop further includes a 2-nd order Phase -Integration (PI) carrier frequency loop, and wherein said step (G) of averaging said phase angle error by using said carrier loop filter further includes the step of:

determining a set of (P)-phase and (I)- integration coefficients for said 2-nd order Phase -Integration (PI) carrier frequency loop by using a state machine depending on clock counts, a measured average constellation error, and at least one error threshold.

8. The method of claim 1, wherein said carrier frequency loop further includes a 3-d order Phase -Integration-Derivative (PID) carrier frequency loop, and wherein said step (G) of averaging said phase angle error by using said carrier loop filter further includes the step of:

determining a set of (P)-phase, (I)- integration, and (D)-derivative coefficients for said 3-d order Phase -Integration-Derivative (PID) carrier frequency loop by using a state machine depending on clock counts, a measured average constellation error, and at least one error threshold.

9. The method of claim 1, wherein said step (E) of using said complex conjugate multiplier to obtain said phase angle error for each said symbol clock further includes the step of:

averaging a DC offset correction for said sampled QAM BE signal by averaging said DC offset in said I channel to obtain an I_{DC} offset and by averaging said DC offset in said Q channel to obtain a Q_{DC} offset.

10. The method of claim 1, wherein said step (F) of computing said instantaneous phase angle error used by said carrier loop filter further includes the step of:

using a quasi-linear phase detector.

11. The method of claim 1,wherein said step (F) of computing said instantaneous phase angle error used by said carrier loop filter further includes the step of:

using a quasi-linear phase detector to approximate said phase angle error signal as a one-bit directional error step function.

12. The method of claim 1, wherein said step (F) of computing said instantaneous phase angle error used by said carrier loop filter further includes the step of:

using a quasi-linear phase detector to approximate said phase angle error signal as a multi-bit function.

13. The method of claim 1, wherein said step (F) of computing said instantaneous phase angle error used by said carrier loop filter further includes the step of:

using a quasi-linear phase detector to approximate said phase angle error signal as a multi-bit tan^{-1} function.

14. The method of claim 13, wherein said step of using said quasi-linear phase detector to approximate said phase angle error signal as said multi-bit tan^{-1} function further includes the steps of:

normalizing I and Q components of said phase angle error signal;

reciprocating (inversing) said normalized I component of said phase angle error signal;

multiplying said normalized Q component of said phase angle error signal and inversed normalized I component of said phase angle error signal;

and

approximating said multi-bit tan^{-1} function by said normalized Q component of said phase angle error signal multiplied by said inversed normalized I component of said phase angle error signal.

15. The method of claim 1, wherein said step (F) of computing said instantaneous phase angle error used by said carrier loop filter further includes the step of:

setting a variable bandwidth of said carrier loop filter in order to minimize said carrier loop filter bandwidth and in order to optimize the bit error rate (BER).

16. The method of claim 15, wherein said carrier frequency loop further includes a 3-d order Phase-Integration-Derivative (PID) carrier frequency loop, and wherein said step of setting said variable bandwidth of said carrier loop filter further includes the step of:

selecting an initial set of PID coefficients by using said state machine to set said variable bandwidth of said carrier loop filter to be higher than a frequency

uncertainty during a QAM signal acquisition state of said QAM demodulator; and

adjusting said initially selected set of PID coefficients by using said state machine in order to decrease said initially set bandwidth of said carrier loop filter in incremental stages to be less than said frequency uncertainty during a carrier tracking state of said QAM demodulator.

17. The method of claim 15, wherein said step of setting said variable bandwidth of said carrier loop filter further includes the steps of:

monitoring an average QAM constellation phase angle error;

obtaining an average amplitude error power of said QAM constellation; and

switching said bandwidth to a lower value based on said average power of said constellation by using said state machine.

18. The method of claim 17, wherein said step of obtaining said average amplitude error power of said QAM constellation further includes the step of:

performing an exponential averaging to get said average amplitude error power of said QAM constellation.

19. The method of claim 15, wherein said step of setting said variable bandwidth of said carrier loop filter further includes the steps of:

(A) starting with a first set of coefficients of said carrier frequency loop in said state machine corresponding to a normal set of input code words;

(B) detecting a burst set of input code words;

(C) selecting a second set of coefficients of said carrier frequency loop in said state machine corresponding to said burst set of input code words for a predetermined amount of time to switch said QAM modem to a burst mode of operation;

(D) switching said state machine back so that to set said carrier frequency loop includes said first set of coefficients after said burst mode is over; and

(E) repeating said steps (A-D).

20. An apparatus for robust carrier recovery in a QAM demodulator, said apparatus comprising:

a sampling block configured to sample a QAM signal received from a transmission channel;

a symbol clock recovery block coupled to said sampling block; said symbol clock recovery block configured to recover a symbol clock function from said sampled QAM signal;

an adaptive equalizer coupled to said symbol clock recovery block; said adaptive equalizer configured to transform said sampled QAM signal into a QAM equalized signal in a Blind Equalization (BE) mode; and

a carrier frequency loop;

wherein said QAM input signal includes an input carrier frequency within an acquisition bandwidth of said carrier frequency loop.

21. The apparatus of claim 20, wherein said carrier frequency loop further

includes:

a slicer configured to locate a nearest plant point for said QAM Blind equalized signal for each said recovered symbol clock;

a complex conjugate multiplier coupled to said slicer, said complex conjugate multiplier configured to obtain an instantaneous inphase component and an instantaneous quadrature component of a phase angle error signal by comparing an inphase component and a quadrature component of said QAM Blind equalized signal and an inphase and a quadrature component of said nearest plant point for each said symbol clock;

a linear phase detector configured to translate said inphase component and said quadrature component of said phase angle error signal into an instantaneous phase angle error for each said symbol clock;

a carrier loop filter configured to average said instantaneous phase angle error signal;

and

a complex multiplier configured to insert an inverse of said averaged phase angle error signal into said QAM Blind equalized signal to compensate for said carrier phase angle error.

22. The apparatus of claim 21, wherein said linear phase detector further includes:

an algorithm configured obtain said instantaneous phase angle error for each said symbol clock in a Decision Directed Equalization (DDE) mode.

23. The apparatus of claim 21, wherein said linear phase detector further

includes:

an algorithm configured obtain said instantaneous phase angle error for each said symbol clock in a Blind Equalization (BE) mode.

24. The apparatus of claim 20, wherein said carrier frequency loop further includes a 1-st order Phase (P) carrier frequency loop further including:

a state machine configured to pre-compute a set of (P)- phase coefficients for said carrier loop filter by utilizing a set of clock counts, a measured average constellation error, and at least one error threshold.

25. The apparatus of claim 20, wherein said carrier frequency loop further includes a 2-nd order Phase -Integration (PI) carrier frequency loop further including:

a state machine configured to pre-compute a set of (P)-phase and (I)-integration coefficients for said 2-nd order Phase -Integration (PI) carrier frequency loop by utilizing a set of clock counts, a measured average constellation error, and at least one error threshold.

26. The apparatus of claim 20, wherein said carrier frequency loop further includes a 3-d order Phase -Integration-Derivative (PID) carrier frequency loop further including:

a state machine configured to pre-compute a set of (P)-phase, (I)-integration, and (D)-derivative coefficients for said 3-d order Phase -Integration-Derivative (PID) carrier loop by utilizing a set of clock counts, a measured average constellation error, and at least one error threshold.

27. The apparatus of claim 21, wherein said linear phase detector further includes:

a one-bit quasi-linear phase detector configured to approximate said phase angle error signal as a one-bit directional error step function.

28. The apparatus of claim 21, wherein said linear phase detector further includes:

a multi-bit quasi-linear phase detector configured to approximate said phase angle error signal as a multi-bit directional error step function.

29. The apparatus of claim 28, wherein said multi-bit quasi-linear phase detector further including:

a multi-bit tan^{-1} function quasi-linear phase detector configured to approximate said phase angle error signal as a multi-bit tan^{-1} function.

30. The apparatus of claim 29, wherein said multi-bit tan^{-1} function quasi-linear phase detector configured to approximate said phase angle error signal as said multi-bit tan^{-1} function further includes:

an algorithm comprising the following steps:

(A) normalizing I and Q components of said phase angle error signal;

(B) reciprocating (inversing) said normalized I component of said phase angle error signal;

(C) multiplying said normalized Q component of said phase angle error signal and inversed normalized I component of said phase angle error signal; and

(D) approximating said multi-bit tan^{-1} function by said normalized Q

component of said phase angle error signal multiplied by said inversed normalized I component of said phase angle error signal.

31. The apparatus of claim 26, wherein said carrier frequency loop further includes a 3-d order Phase -Integration-Derivative (PID) carrier frequency loop further including:

a state machine further including:

a first bank of PID coefficients;

and

a second bank of PID coefficients;

wherein said first bank of PID is used to initially set a variable bandwidth of said carrier loop filter to be higher than a frequency uncertainty during a QAM signal acquisition state of said QAM demodulator;

and wherein said second bank of PID coefficients is used to decrease said initially set bandwidth of said carrier loop filter in incremental stages to be less than said frequency uncertainty during a carrier tracking state of said QAM demodulator.

32. The apparatus of claim 26, wherein said carrier frequency loop further includes a 3-d order Phase -Integration-Derivative (PID) carrier frequency loop further including:

a state machine further including:

an average algorithm comprising the following steps:

monitoring an average QAM constellation phase angle error;

obtaining an average amplitude error power of said QAM constellation;

and

switching said bandwidth to a lower value based on said average power of said constellation.

33. The apparatus of claim 26, wherein said carrier frequency loop further includes a 3-d order Phase -Integration-Derivative (PID) carrier frequency loop further including:

a state machine further including:

an exponential averaging algorithm comprising the following steps:

monitoring an average QAM constellation phase angle error;

performing an exponential averaging to get an average amplitude error power of said QAM constellation;

and

switching said bandwidth to a lower value based on said average power of said constellation.

34. An apparatus for robust carrier recovery in a QAM demodulator, said apparatus comprising:

(A) a means for sampling a QAM signal received from a transmission channel;

(B) a means for recovering a symbol clock function from said sampled QAM signal;

(C) a means for obtaining a QAM equalized signal in a Blind Equalization (BE) mode;

(D) a means for locating a nearest plant point for said QAM Blind equalized signal for each said recovered symbol clock;

(E) a means for obtaining an instantaneous inphase component and an

instantaneous quadrature component of a phase angle error signal by comparing an inphase component and a quadrature component of said QAM Blind equalized signal and an inphase and a quadrature component of said nearest plant point for each said symbol clock;

(F) a means for translating said inphase component and said quadrature component of said phase angle error signal into an instantaneous phase angle error for each said symbol clock;

(G) a means for averaging said instantaneous phase angle error signal; and

(I) a means for inserting an inverse of said averaged phase angle error signal into said QAM Blind equalized signal to compensate for said carrier phase angle error.

35. The apparatus of claim 34, wherein said means for translating said inphase component and said quadrature component of said phase angle error signal into said instantaneous phase angle error for each said symbol clock further includes:

a means for obtaining said instantaneous phase angle error for each said symbol clock in a Decision Directed Equalization (DDE) mode.

36. The apparatus of claim 34, wherein said means for translating said inphase component and said quadrature component of said phase angle error signal into said instantaneous phase angle error for each said symbol clock further includes:

a means for obtaining said instantaneous phase angle error for each said symbol clock in a Blind Equalization (BE) mode.

37. An apparatus for robust carrier recovery in a QAM demodulator, said apparatus comprising:

a means for sampling a QAM signal received from a transmission channel;

a means for performing a symbol clock recovery function from said sampled QAM signal;

a means for transforming said sampled QAM signal into a QAM equalized signal in a Blind Equalization (BE) mode;

and

a carrier frequency loop;

wherein said QAM input signal includes an input carrier frequency within an acquisition bandwidth of said carrier frequency loop.

38. The apparatus of claim 37, wherein said carrier frequency loop further includes a 1-st order Phase (P) carrier frequency loop, said apparatus further including:

a state machine configured to determine a set of (P)- phase coefficients for said 1-st order Phase (P) carrier frequency loop by utilizing a set of clock counts, a measured average constellation error, and at least one error threshold.

39. The apparatus of claim 37, wherein said carrier frequency loop further includes a 2-nd order Phase -Integration (PI) carrier frequency loop, said apparatus further including:

a state machine configured to determine a set of (P)-phase and (I)- integration coefficients for said 2-nd order Phase -Integration (PI) carrier frequency loop by utilizing a set of clock counts, a measured average

constellation error, and at least one error threshold.

40. The apparatus of claim 37, wherein said carrier frequency loop further includes a 3-d order Phase -Integration-Derivative (PID) carrier frequency loop, said apparatus further including:

a state machine configured to determine a set of (P)-phase, (I)- integration, and (D)-derivative coefficients for said 3-d order Phase -Integration-Derivative (PID) carrier frequency loop by utilizing a set of clock counts, a measured average constellation error, and at least one error threshold.

41. The apparatus of claim 37 further including:

a means for averaging an instantaneous phase angle error within said carrier loop.

42. The apparatus of claim 41, wherein said means for averaging further includes:

means for approximating said phase angle error signal as a one-bit directional error step function.

43. The apparatus of claim 41, wherein said means for averaging further includes:

means for approximating said phase angle error signal as a multi-bit function.

44. The apparatus of claim 41, wherein said means for averaging further

includes:

means for approximating said phase angle error signal as a multi-bit tan^{-1} function.

45. The apparatus of claim 37 further including:

a means for performing an exponential averaging to get said average amplitude error power of said QAM constellation.